Speech Production and Perception I

User Guide

SENSIMETRICS
Series in Human Communication

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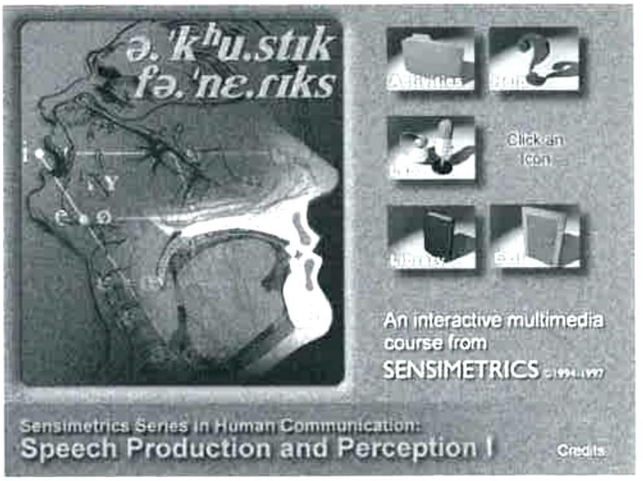
Before starting the course, be sure that you have followed the installation procedure correctly. The installation instructions are in a separate document.



Using the mouse

Only the left mouse button is used in this course, always with a single click. You do not need to worry about whether the right button or a double click is needed.

Selecting resources

The title page has five buttons. These allow you to select from the basic resources of the course. The buttons are on the right side of the page.

Help

The button with the large blue question mark gives you access to the course's help system. To get help, move the mouse cursor so that it is over the **Help** button and click.

Exit

The **Exit** button lets you leave the course so that you can use the computer for something else. To leave the course, move the cursor to the **Exit** button (the door on the button opens when

you do this) and click.

The three resources

The course contains three different resources: *Activities*, *Lab*, and *Library*. Each resource is like a book with a bookmark in it. You can put away the "*Activities* book" and pick up the "*Library* book" to look up an unfamiliar word. The course then saves a bookmark in *Activities* for you. When you return from the *Library*, you will be back at the same place you left earlier.

You can switch among the resources of the course, *Activities*, *Lab*, and *Library*, at any time by clicking the appropriate button (picture). The three buttons for the three resources are on the upper right-hand corner of each page.

Activities

The *Activities* button has a picture of a folder on it. The units in this section of the course deal with topics in Acoustic Phonetics. Each unit covers several related topics. You can study units on your own, or a teacher will give you reading or homework assignments from the *Activities* section.

To go to the *Activities Contents* page, move the cursor to the *Activities* button and click. When you are in *Activities*, the folder shown on that button will be open. When you are in another resource of the course, the folder will be closed.

Lab

The *Lab* button has a picture of a microphone and loudspeaker. The *Lab* section is a laboratory where you can experiment. The computer you use should be equipped with a microphone and an audio card, which are needed to record and play the sounds studied in the course. The audio card and microphone will let you record and compare your own speech and that of others.

You can also use the *Lab* for homework assignments or lab experiments, just as you would go into a chemistry lab to perform chemistry experiments.

To go to the *Lab Contents* page, move the cursor to the *Lab* button and click. When you are in the *Lab* resource, the picture of the microphone in the *Lab* button will be tilted down and the picture will show sound waves coming out of the loudspeaker. When you are in another resource, the microphone will be upright.

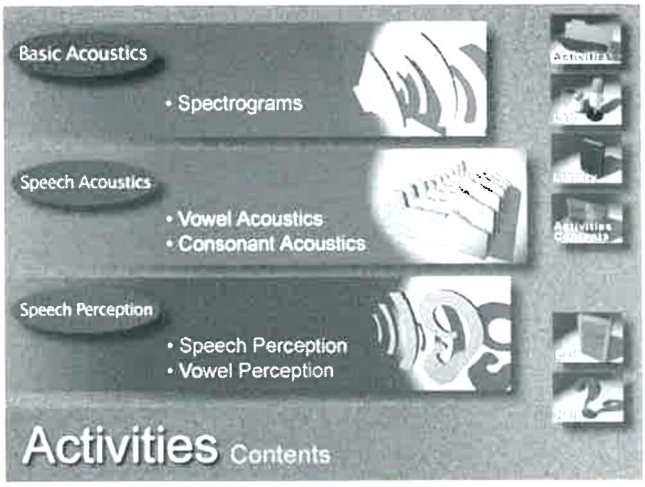
Library

The *Library* button has a picture of a book on it. Like a real library, the course *Library* is a place to look things up. It contains a Glossary with definitions of phonetic and acoustic terms, an IPA Consonant Chart, and an IPA Vowel Chart that you can use to refresh your memory of phonetics. There is also a page of IPA Samples that you can play to hear the vowels and consonants in the charts, and a Bibliography that you can use to find books and articles that tell you more about the subjects in the course.

To go to the *Library Contents* page move the cursor to the *Library* button and click. When you are in the *Library* resource, the book shown on the *Library* button will be open. When you are in another resource of the course, the book will be closed.

Credits

If you click the **Credits** button, in the lower right-hand corner of the title page, you will be shown a list of the people who created the course.

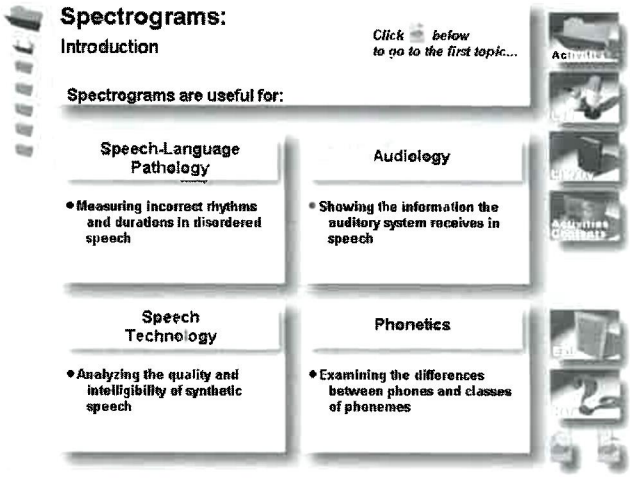


Activities

The *Activities Contents* page lists the units available in the course. The units are in three areas: Basic Acoustics, Speech Acoustics, and Speech Perception. Each of these areas contains one or more units. Basic Acoustics contains the unit Spectrograms. Speech Acoustics includes two units, Vowel Acoustics and Consonant Acoustics. Speech Perception includes the two units, Speech Perception and Vowel Perception. The version of the course that you use may have additional units.

You can tell quickly which area you are looking at by the background color of the screen. The pages in Basic Acoustics have a yellow-brown background, those in Speech Acoustics have a light green background, and those in Speech Perception have a light blue background. The colors of each unit are the same as the others in that area.

Clicking a title takes you to the contents page for that unit.


Spectrograms:
Introduction
Click below to go to the first topic...
Spectrograms are useful for:
Speech-Language Pathology
Measuring incorrect rhythms and durations in disordered speech
Audiology
Showing the information the auditory system receives in speech
Speech Technology
Analyzing the quality and intelligibility of synthetic speech
Phonetics
Examining the differences between phones and classes of phonemes

Unit contents

The unit contents page lists the topics covered in that unit. Each topic is listed with a short title and a **topic** button that contains a small picture of a folder. To go to a topic move the cursor to the title or the button and click.

If you are studying this material on your own, it may be easiest to begin with the first topic in the list and go down the list through the rest of the topics. If you are doing this in a school, your teacher may tell you to go to a specific topic. In either case, you should feel free to browse.

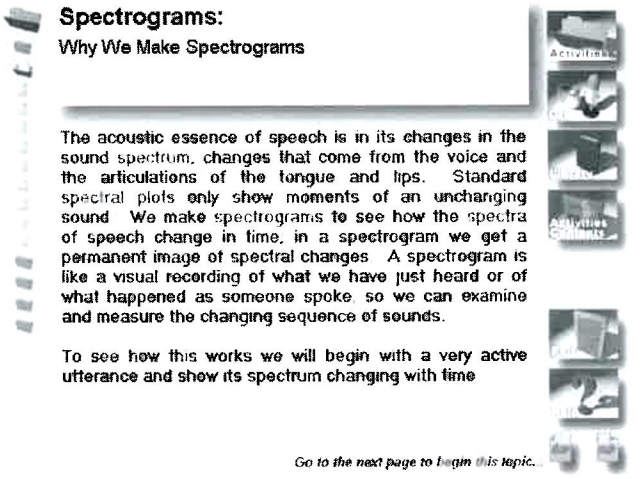
To go back to the *Activities Contents* page click *Activities Contents*. To go to another section of the course (*Lab*, *Library*) click the appropriate button on the top right-hand corner of the page.

Introduction

Each unit begins with an **introduction page**. Acoustic phonetics has applications in Audiology, Computer Science, Linguistics, Speech-Language Pathology, Communications and other fields. The introduction page lists some applications of the content of each unit.

After you read the introduction page, you can go on to other topics, back to the **unit contents** page, back to the *Activities Contents* page, or to the other resources of the course (*Lab*, *Library*). Clicking the **page forward** button in the lower right-hand corner of the page will take you to the first page of the next topic. Clicking the **page backward** button will take you back to the unit contents page. Clicking *Activities Contents* on the right side of the page takes you to that page.

Clicking one of the folders on the left edge of the introduction page will take you to one of the other topics in the unit. See the section "Turning Pages" for a further explanation of how the **page ladder** on the left-hand edge of the page works.


Spectrograms:
Why We Make Spectrograms
The acoustic essence of speech is in its changes in the sound spectrum, changes that come from the voice and the articulations of the tongue and lips. Standard spectral plots only show moments of an unchanging sound. We make spectrograms to see how the spectra of speech change in time. In a spectrogram we get a permanent image of spectral changes. A spectrogram is like a visual recording of what we have just heard or of what happened as someone spoke, so we can examine and measure the changing sequence of sounds.
To see how this works we will begin with a very active utterance and show its spectrum changing with time
Go to the next page to begin this topic...

Topics

After you select a topic by clicking its title or button on the **unit contents** page, you see the first page of the topic. This page is identified by an open folder in the **page ladder** at the left edge of the page. The page contains a description of the problem to solve or the material to analyze in this topic.

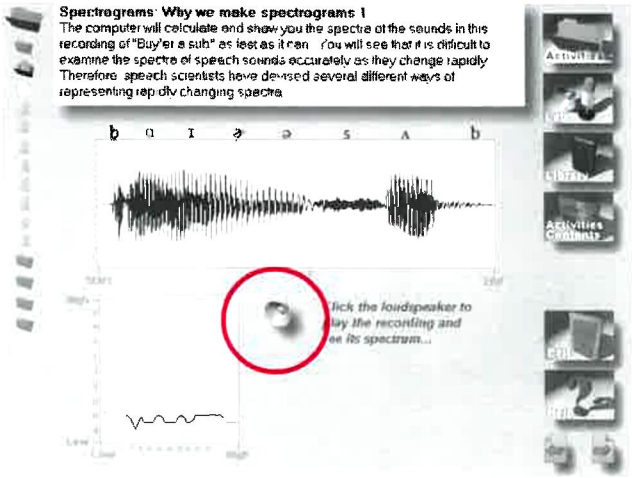
The series of pages related to this topic is displayed in miniature beneath the open folder in the page ladder. As you progress through the topic, the page ladder highlights the page you are working on. You can track your progress through the topic by checking the page ladder. For more information on how to use the page ladder, look at the section "Turning Pages."

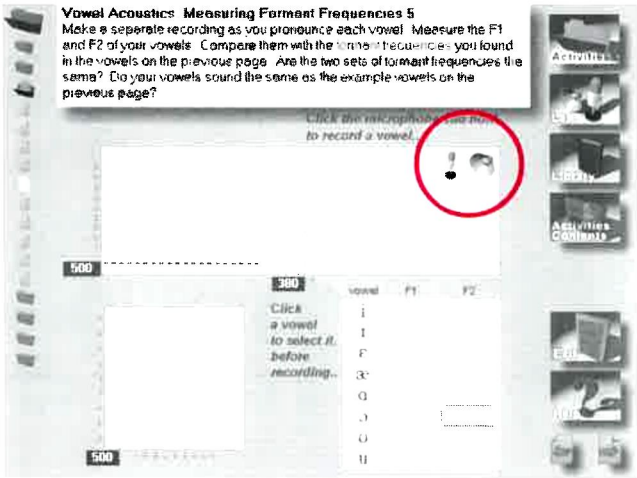
Each topic has a number of pages. Many of the pages have an activity, where you do or observe something. Some topics have pages of notes that illuminate the concepts you have learned about on previous pages. Each topic ends with a summary page that will remind you of the effects you have observed and the concepts you have learned.

The activities

The course contains many different activities. Some activities are simply animations that you look at. Others are simulations of physical processes that you can run in slow motion to see and understand the details of the process. Some activities are synthesizers that you control to create new sounds. Some show models of systems with different inputs; you can select the input to the system, then see or hear how the output changes.

Many screens contain instructions for a specific activity that students (or other users of the course) are expected to perform. Unless they change, the instructions are not repeated on similar pages that follow. The instructions are written in blue italics and are generally next to the controls or buttons you use to control the activity.


Spectrograms: Why we make spectrograms 1
The computer will calculate and show you the spectra of the sounds in this recording of "Buy'er a suh" as fast as it can. You will see that it is difficult to examine the spectra of speech sounds accurately as they change rapidly. Therefore, speech scientists have devised several different ways of representing rapidly changing spectra.
b a ɪ ə ə s ʌ b
Activities
Contents
Library
Edit
Help
Print
Exit



Listening to sounds

If your computer is equipped with a Windows-compatible audio card and a loudspeaker or headphones (see the *Installation Guide*), you can listen to sounds that have been recorded or synthesized. For instance, you can listen to a sound that corresponds to a waveform displayed on a page, as on the example page shown here. You can also listen to a sound shown on a spectrogram, the sound with a specific spectrum, or to speech matching a phonetic transcription. In each case, a loudspeaker icon is somewhere on the page.

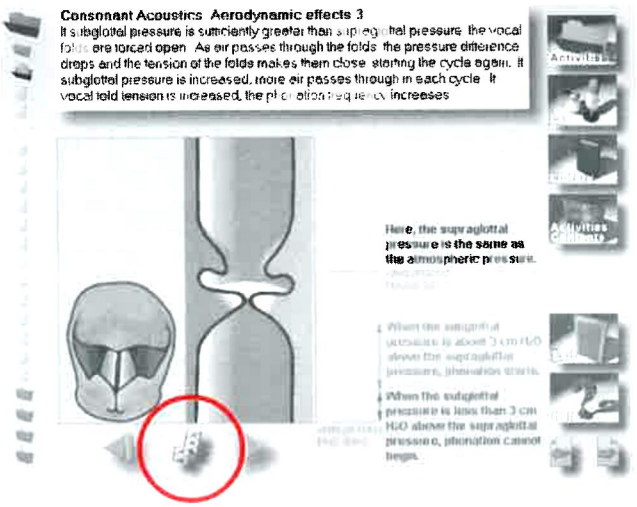
When you see the loudspeaker icon on the graph of a waveform, spectrogram, or spectrum, move the cursor to the loudspeaker and hold the mouse button down to play the sound. If the loudspeaker icon is on the page outside the graph, move the cursor to the loudspeaker and click to play a sound and see its properties change as it plays. In the example shown above, the spectrum under the waveform changes as the sound changes. Observe the change carefully while listening to the sound.

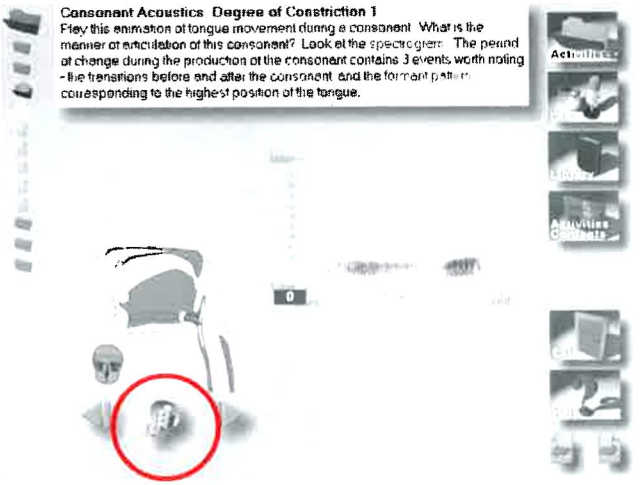
Recording your own sounds

The computer you are using should be equipped with a microphone and a Windows-compatible audio card. That will allow you to record and analyze sounds and voices other than those provided in this course. For example, on the page shown above, you can record yourself speaking a vowel, then see a spectrogram of that vowel. There is a microphone icon on those pages that allow you to record sounds.

You will need to be sure that the computer's audio card is set up properly first. Computers with audio cards contain software that must be adjusted to set the recording level correctly. You will need to set it to make the recording loud enough to be clear, but not too high, to keep distortion low. As audio cards and their software vary, you should read the instructions for the card you are using.

To make a recording, move the cursor to the microphone and hold the mouse button down. While you are holding the button down, the computer will record what you say. When you are finished, let go of the mouse button. On the sample page shown here, the computer calculates the spectrogram of only the final second of your recording.





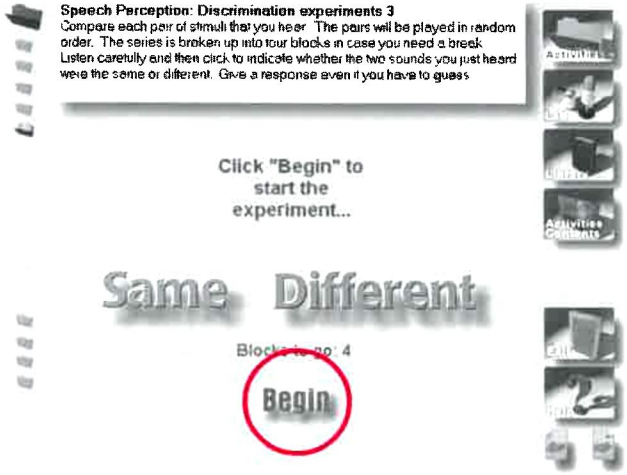
Animations

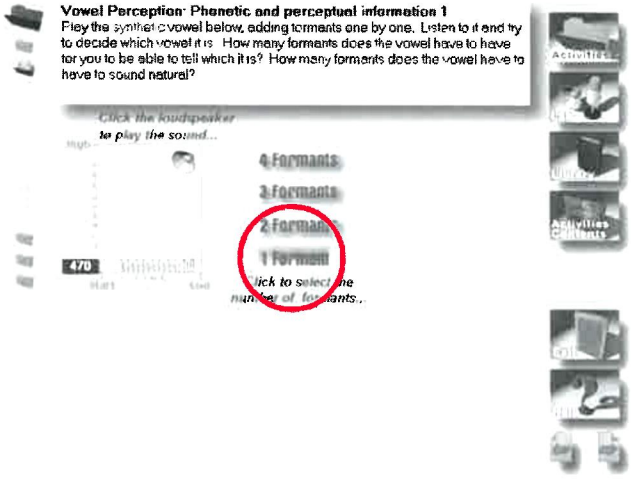
Some pages have animated displays that you can play. Often, you can move the animation forward and backward one frame at a time to observe the process being displayed more carefully. When there is an animation you can play, you see an icon of a filmstrip on the screen. To play an animation, move the cursor to the filmstrip and click.

On pages that let you move the animation forward or backward one frame at a time, you see triangles pointing "forward" and "backward" like those on tape recorders. To move the animation forward one frame, move the cursor to the "forward" arrow (pointing to the right), and click. The animation will move one frame forward. To move the animation backward one frame, move the cursor to the "backward" arrow and click. The animation will move one frame backward.

Some animations also have sound. When an animation has an accompanying sound track, you see an icon of a loudspeaker with a filmstrip coming out of it. Click the loudspeaker + filmstrip to play the animation.
When an animation has a sound track, clicking the "one frame forward" and "one frame backward" icons does not play a sound. Because the sound track is synchronized with the animation, you hear sound only if you play the whole animation.

When you play an animation, be sure to look at the other things shown on the page too. Often, other items change because they are linked to the animation.


Speech Perception: Discrimination experiments 3
Compare each pair of stimuli that you hear. The pairs will be played in random order. The series is broken up into four blocks in case you need a break. Listen carefully and then click to indicate whether the two sounds you just heard were the same or different. Give a response even if you have to guess.
Click "Begin" to start the experiment...
Same
Different
Begin


Vowel Perception: Phonetic and perceptual information 1
Play the synthetic vowel below, adding formants one by one. Listen to it and try to decide which vowel it is. How many formants does the vowel have to have for you to be able to tell which it is? How many formants does the vowel have to have to sound natural?
Click the loudspeaker to play the sound...
4 Formants
3 Formants
2 Formants
1 Formant
470

Buttons

Some pages contain **buttons** you can click. A button can start an activity, an experiment in the case of this sample page. Buttons also play sounds, take you to other pages, and perform many other actions.

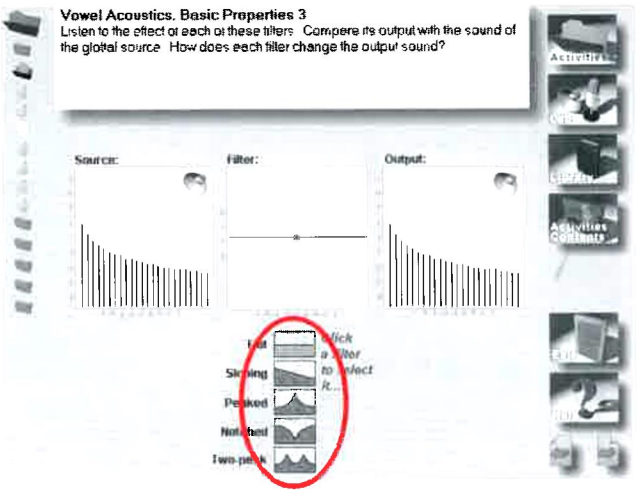
On the sample page shown here, the "Begin" button starts the experiment. As you proceed through the experiment, you click "Same" and "Different" in response to pairs of sounds you hear during the experiment. In other experiments, you might have to click phonetic symbols or graphs.

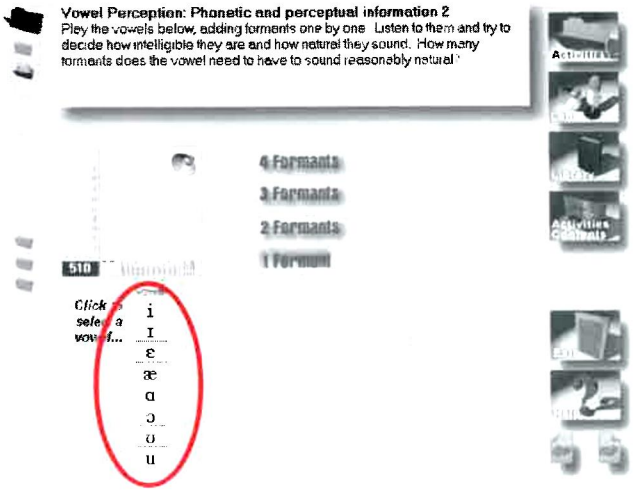
Selections

On many pages, you have some control over what is shown. You do this by selecting from a list of items. On this example page, you control the number of formants used to produce a synthetic vowel. Here, "1 Formant" is selected, so one formant is displayed on the spectrogram.

To select from a list, move the mouse cursor so that it is over one of the items in the list and click. In this case, for example, if "2 Formants" is clicked, two formants will be displayed.

On this page, you can play the synthetic vowel made with the number of formants you have chosen. If you click the loudspeaker icon after selecting "2 Formants", you hear a synthetic vowel made with two formants. You can measure the frequency of each formant by *dragging* the blue handle next to the spectrogram. To drag an object on the screen (if it can be dragged), put the mouse cursor directly over it, press down and hold the mouse button. Then slide the cursor and the object, which will stick together, to the destination you have chosen.


Vowel Acoustics. Basic Properties 3
Listen to the effect of each of these filters. Compare its output with the sound of the glottal source. How does each filter change the output sound?
Source:
Filter:
Output:
Flat
Sloping
Peaked
Notched
Two-peak


Vowel Perception: Phonetic and perceptual information 2
Play the vowels below, adding formants one by one. Listen to them and try to decide how intelligible they are and how natural they sound. How many formants does the vowel need to have to sound reasonably natural?
4 Formants
3 Formants
2 Formants
1 Formant
510
i
ɪ
ɛ
æ
ɑ
ɔ
ʊ
u

This page has a slightly different list of items. You can select from "Flat", "Sloping", "Peaked", and other kinds of filters by clicking the picture of a filter. In this image, the "Flat" filter is selected. When you select a new filter, the graph of the filter above the list changes.

After you select a filter, you can adjust its exact shape by dragging the blue handle in the "Filter" (middle) graph.

In the example above, you can also listen to the "Source" sound, which has the spectrum in the graph on the left side of the page, or the "Output" sound, which has a spectrum that is shown on the right.

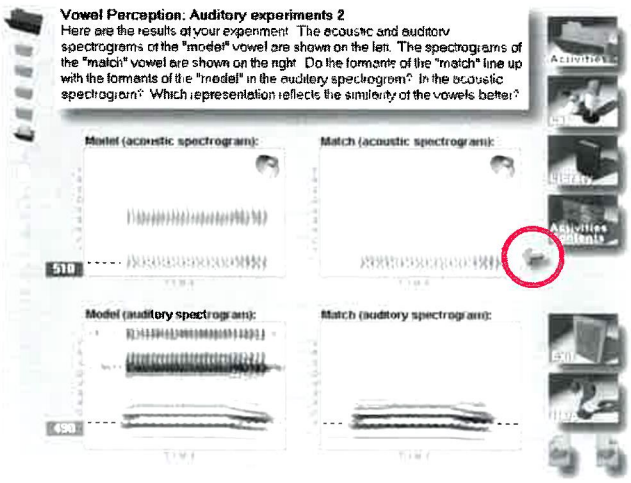
In this example, you select the vowel displayed in the spectrogram. On the actual unit page, the selected vowel is shown with a yellow background and the other vowels are shown with white backgrounds. If you click any other vowel, then that one is shown with a yellow background and the spectrogram changes. At the same time, as the picture shows, you can select the number of formants used to synthesize the vowel.

Other pages display lists of consonants or entire words. When you click one, it is displayed with a yellow background and those that have not been selected are shown with a white background. Usually, something else on the page (for example, a graph of the waveform of a speech sound) is also displayed when you select an item from a list.

Parameters

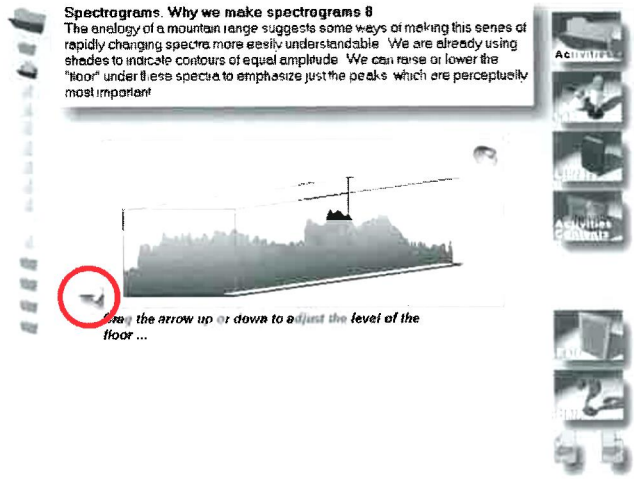
On some pages, you can change a **parameter** of a display or a simulated system. A parameter is a quantity that is variable and that can affect the outcome of a test or experiment. You can usually change a parameter in steps as small or as large as you like. For instance, food intake and exercise can be considered parameters of weight gain; adjusting the amount of food eaten or exercise taken changes the value of weight gain during a given period of time. The two parameters are also independent, because eating and exercising do not necessarily cause each other.

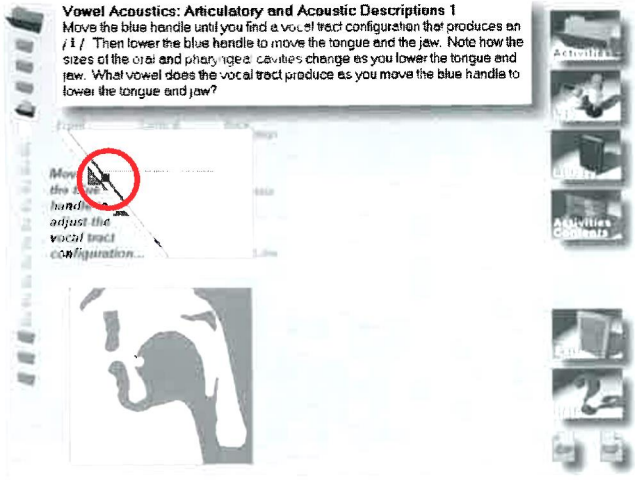
Many pages of the course contain simulations of experiments in which you can adjust the parameters. Sometimes, you will be called upon to adjust the frequency of a tone, and at other times, the location of a formant. Research in most areas of science, including speech science, involves keeping part of a process the same while adjusting an important parameter through its possible range. This is how to learn when a parameter's effect is strongest, and at what point the effect begins or disappears.


Vowel Perception: Auditory experiments 2
Here are the results of your experiment. The acoustic and auditory spectrograms of the "model" vowel are shown on the left. The spectrograms of the "match" vowel are shown on the right. Do the formants of the "match" line up with the formants of the "model" in the auditory spectrogram? In the acoustic spectrogram? Which representation reflects the similarity of the vowels better?
Model (acoustic spectrogram):
Match (acoustic spectrogram):
510
Model (auditory spectrogram):
Match (auditory spectrogram):
490

On this page, a parameter is controlled by the arrow pointer circled on the right side of the page. The arrow points to a formant in the spectrogram. If you move the pointer up or down, the formant frequency changes and the formant moves up or down in the spectrogram. The formant frequency is a parameter you control by moving the pointer.

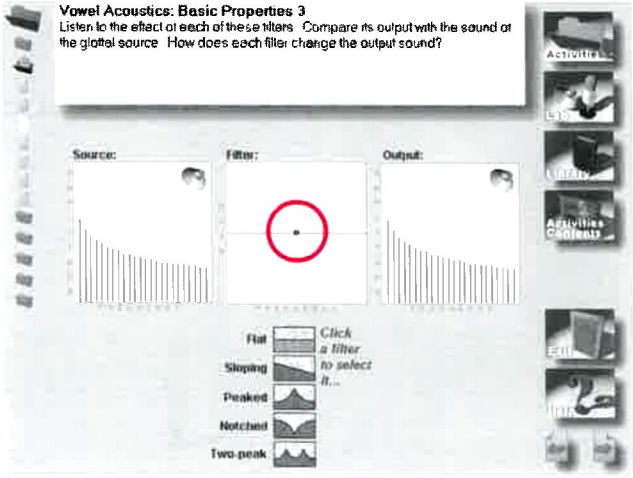
To move the pointer, move the cursor to it, then hold the mouse button down. As you move the mouse while pressing the button, the pointer follows the cursor. This is called "dragging the pointer."

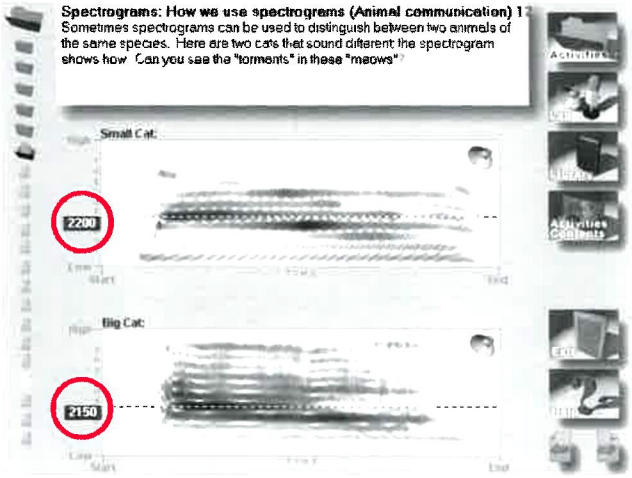

Spectrograms. Why we make spectrograms 8
The analogy of a mountain range suggests some ways of making this series of rapidly changing spectra more easily understandable. We are already using shades to indicate contours of equal amplitude. We can raise or lower the "floor" under these spectra to emphasize just the peaks which are perceptually most important
Drag the arrow up or down to adjust the level of the floor ...


Vowel Acoustics: Articulatory and Acoustic Descriptions 1
Move the blue handle until you find a vocal tract configuration that produces an /i/. Then lower the blue handle to move the tongue and the jaw. Note how the sizes of the oral and pharyngeal cavities change as you lower the tongue and jaw. What vowel does the vocal tract produce as you move the blue handle to lower the tongue and jaw?

This sample page has a parameter similar to the preceding example. The arrow at the left of the page points at the bottom of the "hill-and-valley" plot. If you move the arrow up, the "floor" under the hill-and-valley plot moves up. In this case, the height of the "floor" is a parameter that you control by dragging the pointer.

Here, the handle is in the vowel quadrilateral near the top of the page. Moving the handle changes both the position of the vocal tract shown beneath it and the vowel to be synthesized. As shown, the handle is in position for a front, mid-high vowel. The tongue is forward in the mouth and fairly high (close to touching the roof of the mouth.) Dragging the handle away from its position in the vowel quadrilateral will move the tongue away from its position in the mouth.


Vowel Acoustics: Basic Properties 3
Listen to the effect of each of these filters. Compare its output with the sound of the glottal source. How does each filter change the output sound?
Source:
Filter:
Output:
Flat
Sloping
Peaked
Notched
Two-peak
Click a filter to select it...


Spectrograms: How we use spectrograms (Animal communication) 1
Sometimes spectrograms can be used to distinguish between two animals of the same species. Here are two cats that sound different: the spectrogram shows how. Can you see the "torments" in these "meows"?
Small Cat:
2200
Big Cat:
2150

The control shown in this example, which we have named a "handle," is a small blue square. You move it by dragging, just as in the previous arrow example.

Above, the handle (circled in red) is in the middle of the graph marked "Filter" in the center of the page. Dragging the handle changes a parameter of the filter, and the graph of the filter changes automatically. Of course, there is no circle on the actual page.

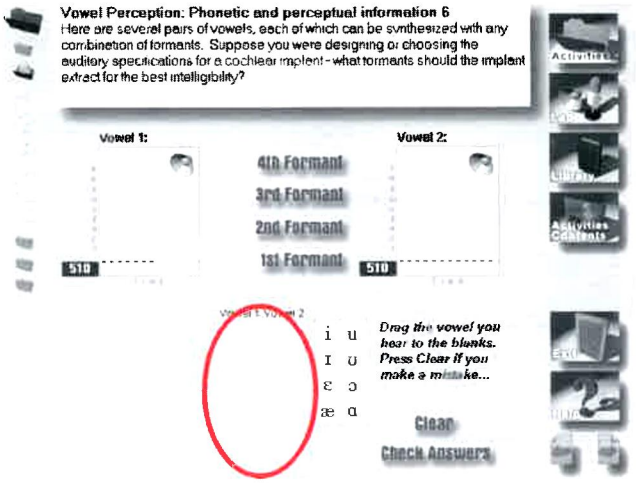
Measurements

On many pages, there are objects that you use to measure properties of a sound without changing the sound. These objects behave like meters, and you use them to measure such properties of a sound as its amplitude or frequency. Meters can be moved by dragging.

On this sample page, the blue boxes beside the spectrograms are meters. To drag a meter, move the cursor to it, hold the mouse button down, and move the mouse. The meter follows the cursor and a dashed line moves over the spectrogram. The meter displays the frequency. In this example, the meter on the upper spectrogram shows a frequency of 2200 Hz and the meter on the lower spectrogram shows a frequency of 2150 Hz.

The movements of meters are constrained. For instance, the meter for measuring frequency on a spectrogram can only move vertically, along the frequency axis. However, you do not need to move the cursor precisely when you drag the meter. Even if you move the mouse diagonally, the meter will track your movement in the vertical direction and ignore the horizontal movement.

In this course, meters are mainly used to measure time or frequency. Meters for measuring amplitude are not used often.


Vowel Perception: Phonetic and perceptual information 6
Here are several pairs of vowels, each of which can be synthesized with any combination of formants. Suppose you were designing or choosing the auditory specifications for a cochlear implant - what formants should the implant extract for the best intelligibility?
Vowel 1:
Vowel 2:
4th Formant
3rd Formant
2nd Formant
1st Formant
510
510
i u
ɪ ʊ
ɛ ɔ
æ ɑ
Drag the vowel you hear to the blanks. Press Clear if you make a mistake...
Clear
Check Answers

Self-test

When you reach the end of some topics, you can test yourself. The page shown here illustrates the kind of self-test available in the course.

In this example, you choose from several questions and put your answers to them on an answer chart. The answer chart shown here is a chart with white and yellow boxes. In this case, you give your answers by putting the correct symbols in the boxes.

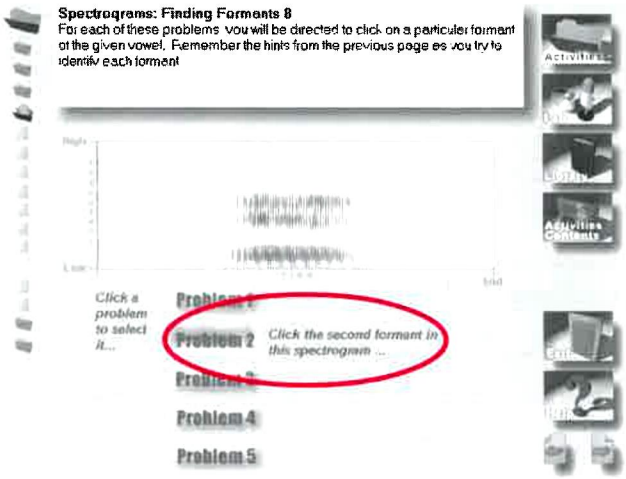
Each of these problems involves listening to two vowels, labeled "Vowel 1" and "Vowel 2". The spectrograms and the two columns of the answer chart are labeled "Vowel 1" and "Vowel 2". The yellow boxes show which of the problems you have chosen. The answer chart has places for 5 more problems and a row of white boxes for each of them. Click a white box to choose a problem. Then listen to the two vowels whose spectrograms are displayed on the page.

After you've chosen a problem and listened to two vowels, answer the questions. State which vowels you think you've heard by dragging their IPA symbols to the selected problem space. If you think you heard an /i/ for Vowel 1, drag the symbol for an /i/ into the yellow box in the chart under "Vowel 1". If you think you heard an /u/ for Vowel 2, drag the symbol for an /u/ to the yellow box in the chart under "Vowel 2".

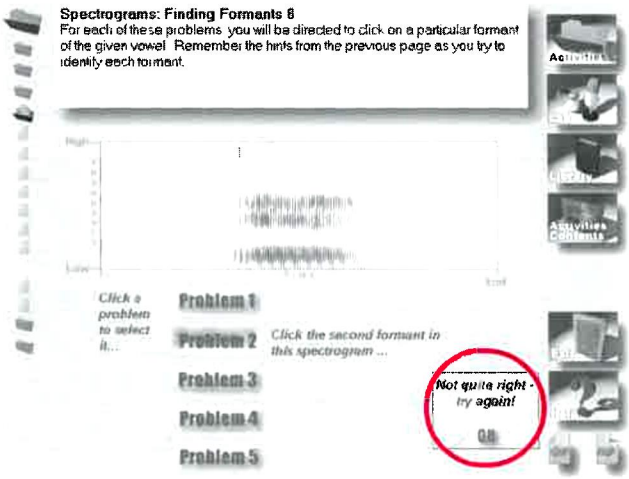
To drag a symbol, move the cursor to it. Press and hold the mouse button down while moving the cursor to the yellow box you want to put the symbol into. A picture of the symbol will follow the cursor. When the cursor is over the correct place in the answer chart, let go of the mouse button. The symbol will drop into the box in the answer chart.

After you've answered some (or all) of the problems, click "Check Answers". The program will check your answers and tell you whether or not they are correct. If one of the answers is wrong, the program will select the problem that was not correctly answered and tell you to try again.

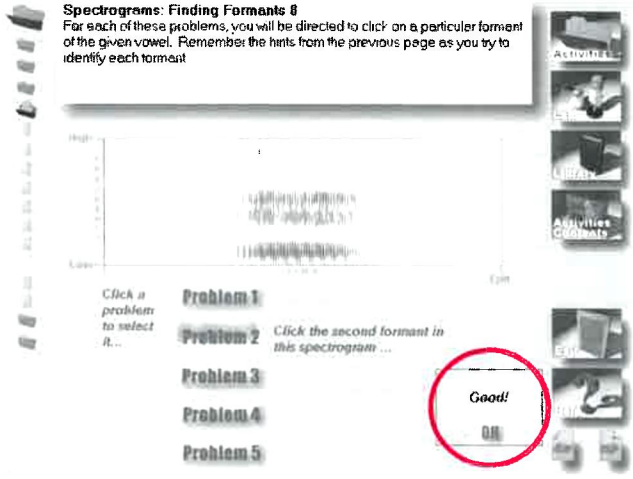
If you want to try all of the problems again, click "Clear" to erase all of the answers. Then select a problem, listen to the vowels, and put the correct symbols in the answer chart.

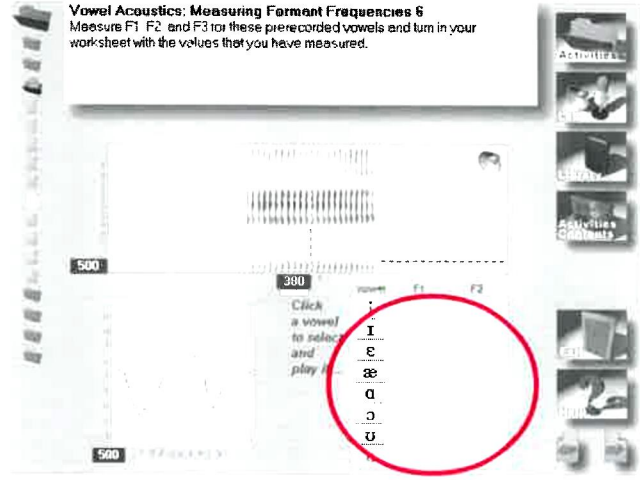

Spectrograms: Finding Formants 8
For each of these problems you will be directed to click on a particular formant of the given vowel. Remember the hints from the previous page as you try to identify each formant
Click a problem to select it...
Problem 2
Click the second formant in this spectrogram ...
Problem 4
Problem 5

Here is another sample self-test page. On this page, you select the problem you want to work on by clicking one of the problems listed. In the example, as shown, "Problem 2" is selected. Notice the instructions that appear beside the "Problem 2" button. The instructions tell you what to do in the problem; in this case, "Click the second formant in this spectrogram".


Spectrograms: Finding Formants 8
For each of these problems you will be directed to click on a particular formant of the given vowel. Remember the hints from the previous page as you try to identify each formant.
Click a problem to select it...
Problem 1
Problem 2
Click the second formant in this spectrogram ...
Problem 3
Problem 4
Problem 5
Not quite right - try again!
OK

This page shows what happens if you make a mistake when you answer a problem. If you click on the wrong formant in the spectrogram, you get a message. In this case, the message is, "Not quite right - try again!" Click "OK" to make the message go away. Click again on a different band that you believe is the second formant. When you do, you will again get a message that tells you whether or not your answer was correct.


Spectrograms: Finding Formants 8
For each of these problems, you will be directed to click on a particular formant of the given vowel. Remember the hints from the previous page as you try to identify each formant
Click a problem to select it...
Problem 1
Problem 2
Problem 3
Problem 4
Problem 5
Click the second formant in this spectrogram ...
Good!
OK



This page shows what happens when you give the correct answer. The message box appears, but this time the message is "Good!" In addition, the second formant is now highlighted (colored blue) on the spectrogram.

Click "OK" to make the message go away or click another "Problem ..." button to try another problem.

Homework

Some topics end with a homework assignment. You can write your answers on a worksheet that an instructor will read later, or you can put your answers on an answer chart on screen. If your computer system is set up to print a picture of the computer screen, you can give that printed picture to your instructor. Pages with homework do not have "Check Answers" buttons or messages that pop up to tell you how you are doing.

The homework page shown in this example offers several problems, each for a different vowel. Each row of the answer chart contains the symbol for the vowel that is the subject of that problem. The other columns of the answer chart are labeled "F1" and "F2," the two things that you need to measure to answer the problem. Select one of the problems by clicking a vowel. This turns a row of boxes in the chart yellow. Then choose whether you want to measure F1 or F2 by clicking one of the boxes in the yellow row. In this example, F1 is selected (the bright yellow box just to the right of the selected vowel).

To fill in a space in the answer chart, make a measurement by dragging the frequency meter onto the spectrogram. When you move the meter to the spectrogram and let go of the mouse button, the frequency shown on the meter is automatically entered in the answer chart. After filling in F1, click the third box in the selected row under the label "F2". The box you click on will turn bright yellow. Next, move the meter until it shows the frequency of F2 in the spectrogram and let go of the mouse button. This will record your measurement of F2 in the selected box.

Turning pages

When you are finished with a page, you can go to the next page, go back to the previous page to review, or jump to other pages or topics in the same unit.

Remember that a screen button needs only a single mouse-click. Move the mouse until the cursor is over one of the buttons and click.

Going to the next page

The **page forward** button at the bottom right of the page takes you to the next page. If you are at the end of a topic, you will be taken to the first page of the next topic. If you are at the end of the unit, clicking **page forward** takes you back to the *Activities Contents* page.

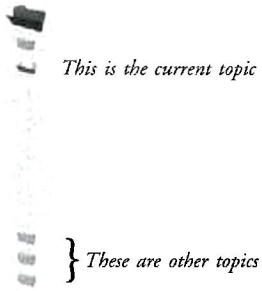
Going back to the previous page

The **page backward** button at the bottom right of the page lets you return to the previous page. If you are at the beginning of the topic, you will go back to the last page of the previous topic. If you are at the beginning of the unit, clicking **page backward** takes you to the *Activities Contents* page.

Going to other pages in the same topic

The **page ladder** on the left edge of the page represents the topics in the unit, and the pages in the topic that you are working on now. Each folder in the page ladder represents a topic; the pages in a topic are shown as slips of paper. The highlighted picture of a slip of paper in the page ladder shows the page you are currently looking at.

To go to a different page in the unit, click its slip of paper in the page ladder. Clicking a slip above the highlighted slip takes you to a page before the current page; clicking on a slip below the highlighted slip takes you to a page that follows the current page. Clicking the picture of the open folder in the page ladder takes you to the first page of the topic.



Going to other topics

The **page ladder** on the left edge of the page contains pictures of **folders**. Each folder corresponds to one of the topics listed on the **unit contents** page at the beginning of the unit.

Clicking one of the closed folders takes you to the first page of that topic. Clicking a folder above the open folder takes you to the first page of a topic that comes before the current topic; clicking a folder below the open folder takes you to the first page of a topic that comes after the current topic. Clicking the open folder takes you to the first page of the current topic.

Going back to the unit contents

At the top of the **page ladder** on the left edge of the page is an open **folder** that represents the current unit. Clicking the open folder at the top of the page ladder takes you to the unit contents page for the current unit.

Going back to the resource contents

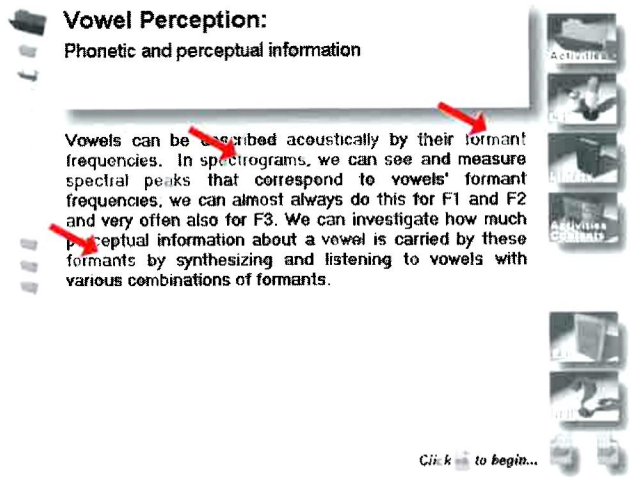
There is a button on the right side of the page that takes you back to the contents page of the resource you are using. When you are in the *Activities* component of the course, the button is labeled *Activities Contents*. When you click it, you return to the *Activities Contents* page. If you are in a different component of the course, click *Activities* first, then *Activities Contents*.

When you are in the *Lab*, there is a button labeled *Lab Contents*; clicking it takes you to the *Lab Contents* page. To go to the contents pages of the other components, click *Activities* or *Library* first, then click *Activities Contents* or *Library Contents*, respectively.

When you are in the *Library*, there is a button labeled *Library Contents*. If you want to go to the *Activities Contents* or the *Lab Contents* pages, click *Activities* or *Lab*, and then click *Activities Contents* or *Lab Contents*.

Going to a different resource

To go to any of the resources of the course (*Activities*, *Library*, or *Lab*), click the corresponding buttons in the upper right corner of the screen. If you click the button for the resource you are already in, nothing happens. If you click the button for a different resource, you are taken to it. If it is a resource that you have not yet visited, you are taken to the contents page for that resource (the *Activities Contents* page, the *Lab Contents* page, or the *Library Contents* page.) If you have gone to the resource before, you return to the page that you were in before. For example, if you visited the Glossary when you were last in the *Library*, then clicking on the *Library* button returns you to the Glossary. To return to your current page, click *Activities* in the upper right corner of a page.


Vowel Perception:
Phonetic and perceptual information
Vowels can be described acoustically by their formant frequencies. In spectrograms, we can see and measure spectral peaks that correspond to vowels' formant frequencies, we can almost always do this for F1 and F2 and very often also for F3. We can investigate how much perceptual information about a vowel is carried by these formants by synthesizing and listening to vowels with various combinations of formants.
Click to begin...

Looking up a word in the Library Glossary

The first time a technical term is used, it is printed in blue. Such a blue word or phrase is a ***hotword***; several hotwords are indicated by arrows on the above sample. In the topic summary, technical terms are also shown as blue hotwords. Clicking a hotword takes you to the Glossary in the *Library* and shows a definition of that word or phrase. After you have read the definition (and those of any related terms that you want to read about in the Glossary), you can return to your current *Activities* page by clicking *Activities* on the upper right corner of the page.

Getting Help

Every page contains the **Help** button, which has a blue question mark on it. When you click **Help**, you get help specifically for the kind of page you are using. If you ask for help while you are looking at a unit contents page, you get help for that kind of page. You do not get help on the concepts or content of a page. If you need help understanding a page, ask for help from your teacher or a TA.

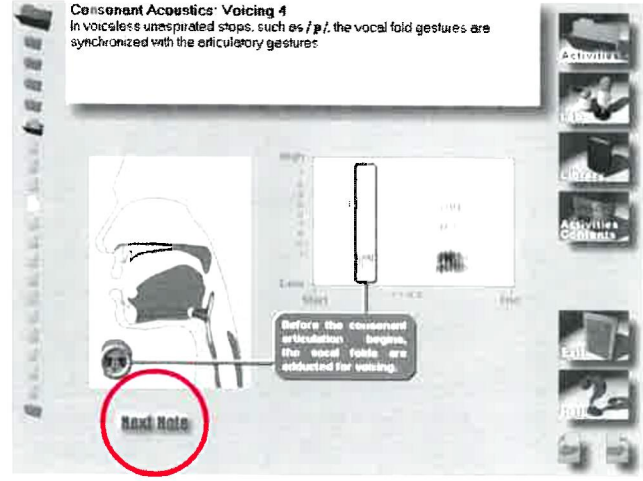
When you have finished using the **Help** system, click **Exit Help** to return to the page you were looking at when you asked for help.

Exiting the course

The **Exit** button has a picture of a door on it. Clicking **Exit** ends the course. When you exit the course, your places in the three resources are not saved. The next time you enter the course, you will begin at the **Title Page** again.

Notes

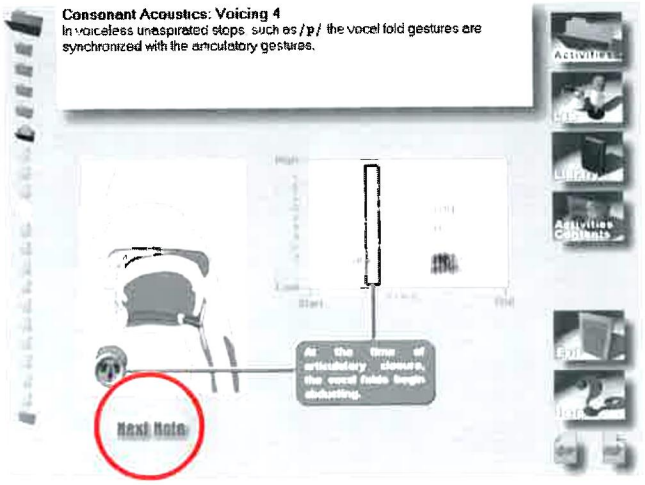
In many topics, there are pages with notes that help you organize or summarize what you have learned. You cannot learn everything from the notes, but the notes can help you select and understand the most important points. Notes are displayed in text on a green panel on a picture of the page you have been using. Often a note has pointers to important parts of the page. If you have trouble understanding a note, you should go back to the page itself and try its activities while looking at the parts of the page indicated in the note.


Consonant Acoustics: Voicing 4
In voiceless unaspirated stops, such as /p/, the vocal fold gestures are synchronized with the articulatory gestures
Next Note

Reading notes

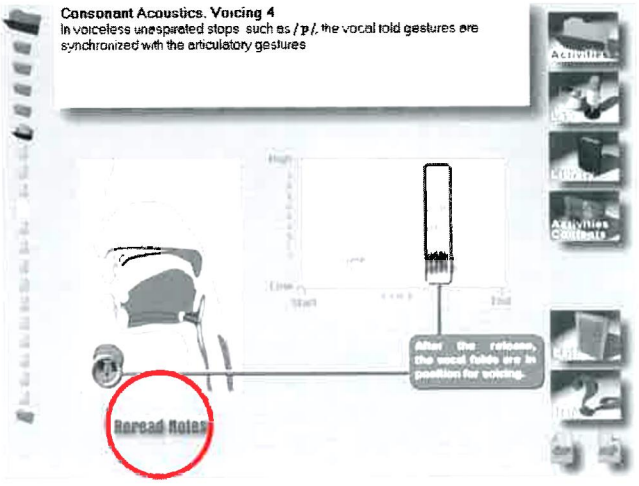
When there is a series of notes on a page, you will see a button like the one that says "Next Note" on this example. First read the note on the screen, then move the cursor to "Next Note" and click the mouse button to see the next note.

In this example, the note shows that there is a connection between the state of the larynx, shown in the animation on the left, and the sound produced by the vocal tract, shown in the spectrogram on the right. Many notes have "loops" like these or arrows that outline or point to important items.


Consonant Acoustics: Voicing 4
In voiceless unaspirated stops such as /p/ the vocal fold gestures are synchronized with the articulatory gestures.
Next Note

Here is the next note on this page. When you see the sign, "Next Notes," continue clicking on it until you have seen the entire sequence of notes. This page has six notes. As you go through the notes, you will see that the notes call your attention to different places on the page. Each note discusses something different that is on the page.

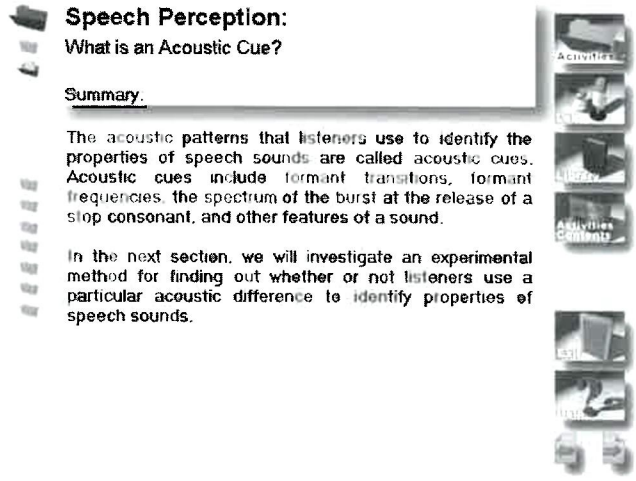
When you reach the last note of the sequence, the button changes to "Reread Notes".

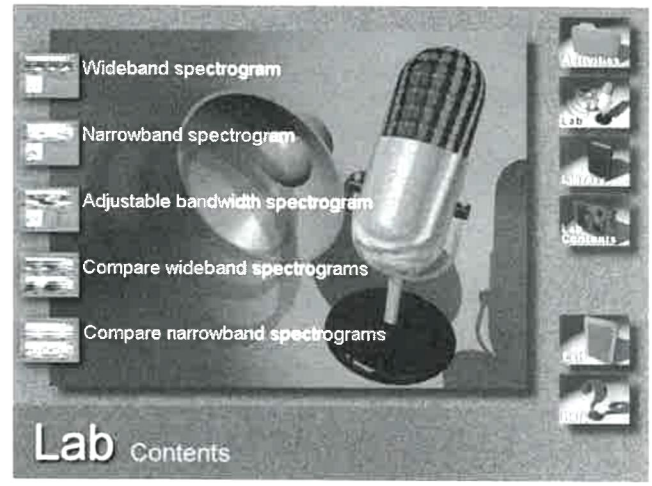

Consonant Acoustics. Voicing 4
In voiceless unaspirated stops such as /p/, the vocal fold gestures are synchronized with the articulatory gestures
Reread Notes

Rereading notes

When you have reached the last note in a sequence, the "Next Note" button changes. On the example page shown here, the button now says "Reread Notes". If you click that button, you go back to the beginning of the sequence of notes. The button changes back to "Next Note".

You can go on to the next page at any time. However, we encourage you to read the whole sequence of notes before you go to the next page.


Speech Perception:
What is an Acoustic Cue?
Summary.
The acoustic patterns that listeners use to identify the properties of speech sounds are called acoustic cues. Acoustic cues include formant transitions, formant frequencies, the spectrum of the burst at the release of a stop consonant, and other features of a sound.
In the next section, we will investigate an experimental method for finding out whether or not listeners use a particular acoustic difference to identify properties of speech sounds.

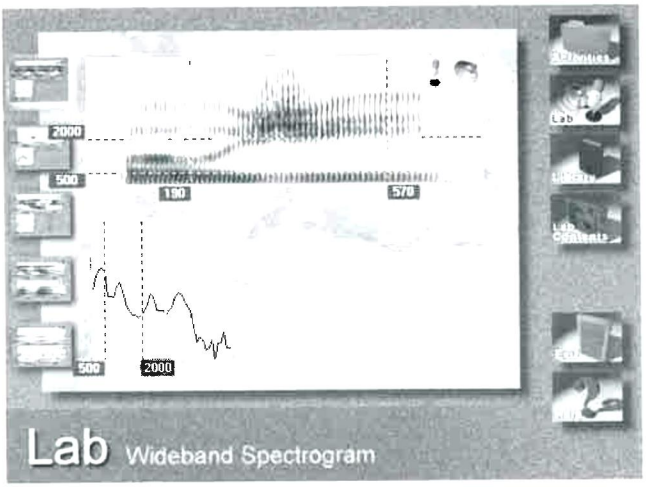


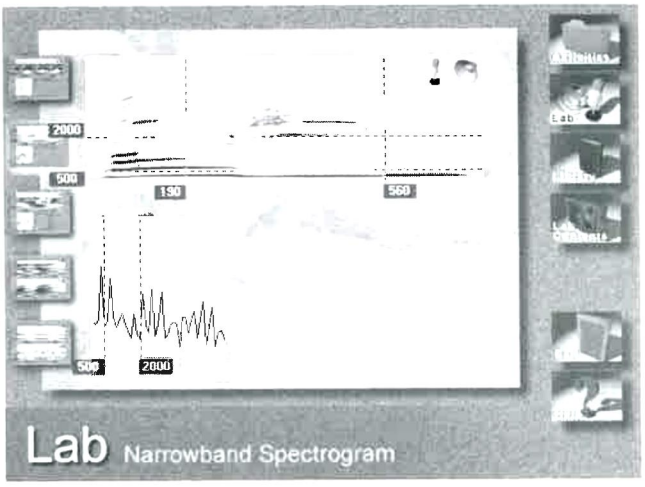
Summary

At the end of a topic, there is a summary page. The summary page contains brief comments on the activities you have just completed. The summary page does not repeat everything you have just learned from the activities, but you can use it to remember which new concepts have been covered in the topic. After reading a summary page, go on to the next topic.

Lab

The *Lab* is a place for you to try out experiments that are not a part of the course. Your instructor may also give you assignments to do in the *Lab*. The *Lab* has five tools for making spectrograms and analyzing speech. They are listed on the *Lab Contents* page shown here. Each one of the tools is on a separate page of the *Lab*. The five pages are entitled the **Wideband spectrogram**, **Narrowband spectrogram**, **Adjustable bandwidth spectrogram**, **Compare wideband spectrograms**, and **Compare narrowband spectrograms** pages. The buttons on the left edge of the page allow you to go to any one of these pages.





Wideband spectrogram

On the **Wideband spectrogram** page you can make a wideband spectrogram of a sound that you have recorded. The page also includes a spectrum display, near the left-hand time cursor, that shows the short-term spectrum of the sound. Use the frequency cursors at the left edge of the spectrogram or at the bottom of the spectrum to measure frequencies, and the time cursors along the bottom of the spectrogram to measure times and durations.

The wideband spectrogram is useful for measuring formant frequencies and the durations of vowels and consonants. It is not very useful for inspecting individual harmonics.

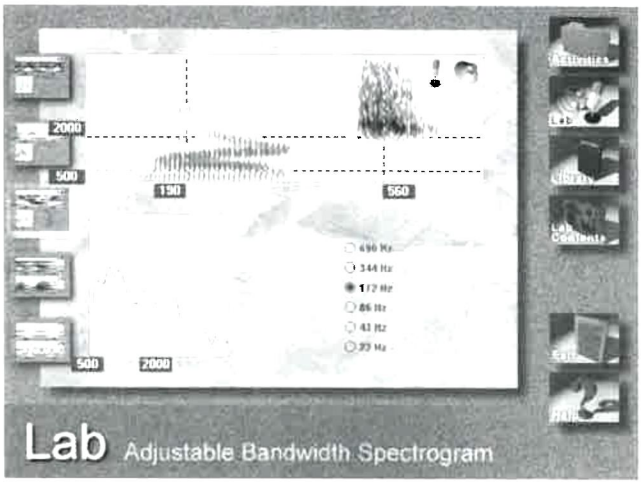
The buttons along the left edge of this page take you to any of the tools in the *Lab*.

Narrowband spectrogram

The **Narrowband spectrogram** page allows you to make a narrowband spectrogram of a sound that you record. The page also includes a spectrum display, near the left-hand time cursor, that shows the short-term spectrum of the sound. You can use the frequency cursors at the left edge of the spectrogram, or under the spectrum, to measure frequencies, and the time cursors along the bottom of the spectrogram to measure times and durations.

The wideband spectrogram is useful for measuring the frequencies of harmonics. It is not very useful for measuring times or durations.

The buttons along the left edge of this page allow you to go to any of the tools in the *Lab*.

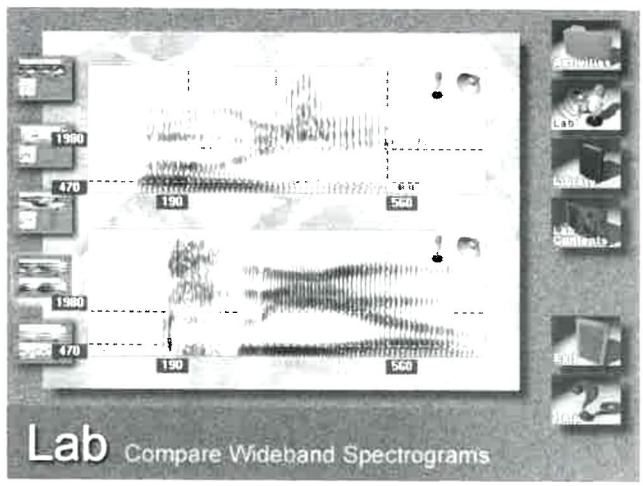


Adjustable bandwidth spectrogram

The **Adjustable bandwidth spectrogram** page allows you to analyze a recorded sound in several different ways by changing the bandwidth of the spectrogram. The page also includes a spectrum display near the left-hand time cursor that shows the short-term spectrum of the sound. When you change the bandwidth of the spectrogram, the spectrum also changes.

As you make the bandwidth larger, the time measurement becomes more precise, while the frequency measurement "spreads out" and loses precision. As you make the bandwidth narrower and the frequency measurement becomes more exact, the time measurement becomes blurred and less precise. You can use the frequency cursors at the left edge of the spectrogram or at the bottom of the spectrum to measure frequencies, and the time cursors along the bottom of the spectrogram to measure times and durations.

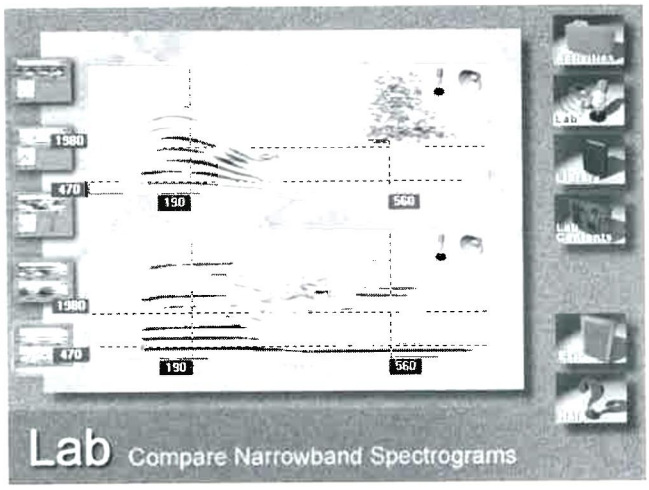
The buttons along the left edge of the page allow you to go to any of the tools in the *Lab*.



Compare wideband spectrograms

This page allows you to record two sounds and make a wideband spectrogram of each one. The two spectrograms are displayed one above the other so that you can compare them easily. You can measure frequency in each spectrogram, using the frequency cursors at its left edge, and measure time using the time cursors under each spectrogram.

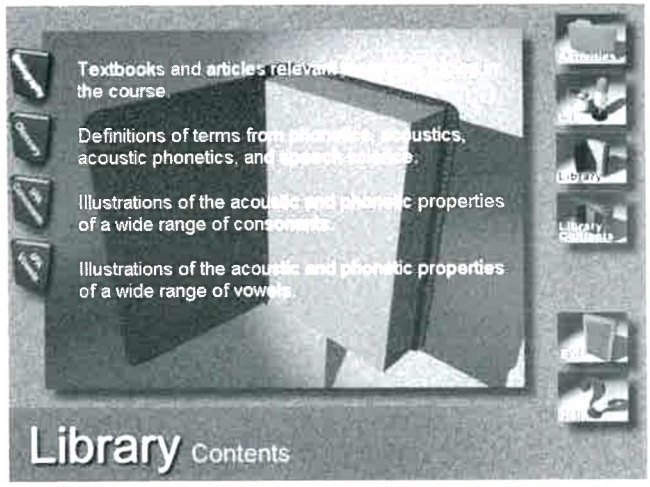
The buttons along the left edge allow you to go to any of the tools in the *Lab*.



Compare narrowband spectrograms

This page allows you to record two sounds and make a narrowband spectrogram of each one. The two spectrograms are displayed one above the other for easy comparison. You can measure frequency on each one, using the frequency cursors at the left edge of each spectrogram, and measure time using the time cursors under each spectrogram.

The buttons along the left edge of the page allow you to go to any of the tools in the *Lab*.

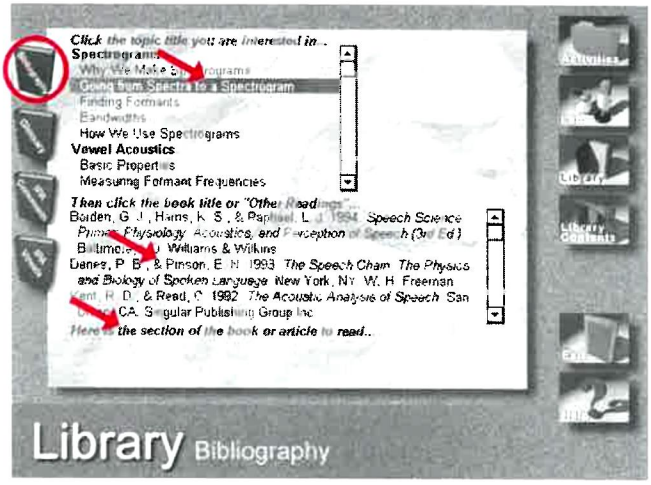


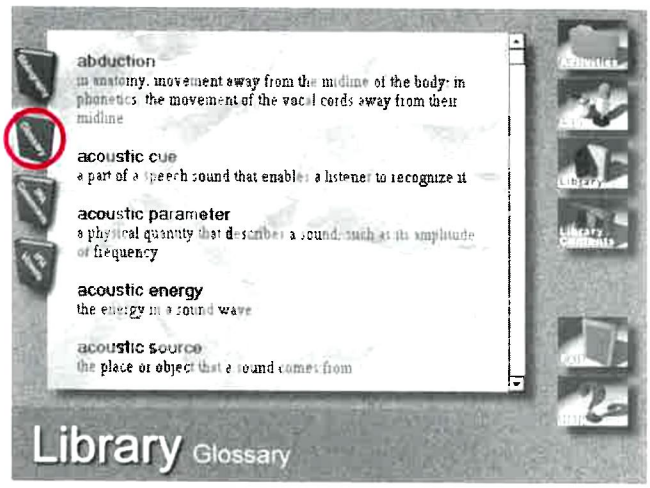
Library

The *Library Contents* page lists the contents of the course *Library*.

You can go to each section of the *Library* by clicking the corresponding button on the left edge of the screen. Use these buttons to switch among the different sections of the *Library* at any time. You can also go to a section of the *Library* by clicking its description in white text in the center of the page.

When you are in the *Library*, you can go back to your page in *Activities* or *Lab* by clicking *Activities* or *Lab* on the right-hand edge of the page. If you were not working in *Activities* or *Lab*, then clicking *Activities* or *Lab* takes you to the *Activities Contents* or *Lab Contents* pages, respectively.


Click the topic title you are interested in...
Spectrograms
Why We Make Spectrograms
Finding Formants
Bandwidths
How We Use Spectrograms
Vowel Acoustics
Basic Properties
Measuring Formant Frequencies
Then click the book title or "Other Readings"
Borden, G. J., Harris, K. S., & Raphael, L. J. 1994. Speech Science
Primer: Physiology, Acoustics, and Perception of Speech (3rd Ed.)
Baltimore: Williams & Wilkins
Denes, P. B., & Pinson, E. N. 1993. The Speech Chain: The Physics
and Biology of Spoken Language. New York, NY: W. H. Freeman
Kent, R. D., & Read, C. 1992. The Acoustic Analysis of Speech. San
Diego, CA: Singular Publishing Group Inc.
Then click the section of the book or article to read..
Activities
Library
Library Contents
Exit
Help
Library Bibliography


abduction
in anatomy, movement away from the midline of the body; in
phonetics, the movement of the vocal cords away from their
midline
acoustic cue
a part of a speech sound that enables a listener to recognize it
acoustic parameter
a physical quantity that describes a sound, such as its amplitude
or frequency
acoustic energy
the energy in a sound wave
acoustic source
the place or object that a sound comes from
Activities
Library
Library Contents
Exit
Help
Library Glossary

Bibliography

The *Bibliography* provides references to textbooks that contain treatments of some of the material covered in this course. You can look up references for each topic in each of the units of the course.

The top panel of the *Bibliography* page lists the topics of the course. For instance, the second topic in the unit of **Vowel Acoustics** is "Measuring Formant Frequencies". The second panel lists several common textbooks in acoustic phonetics, phonetics, and speech science. The third panel lists those sections of the book that are relevant to the topic, if there are any.

Look for references to a topic by clicking the topic you are interested in and the book you are using. The chapter or pages of the book you should read will be displayed at the bottom of the screen.

Glossary

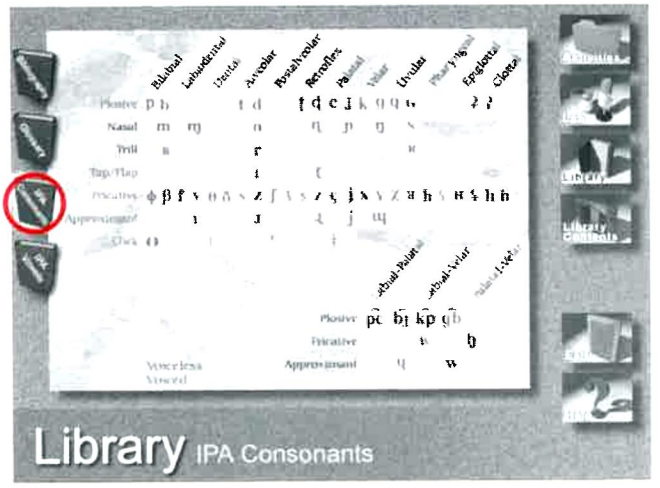
The *Glossary* contains a list of specialized terms used in the course and their definitions. If you are already on the *Glossary* page, you can find a term by scrolling through the alphabetized list. To do this, move the cursor to the small gray box in the gray scroll-bar at the right of the list of terms and definitions. Press and hold down the mouse button while pulling the box down the scrollbar. You will see the list of terms scroll down through the alphabet. You can move up and down the list by moving the box in the scrollbar up and down while holding the mouse button down. When you let go of the mouse button, the list of terms stops moving.

You can also scroll through the list by clicking the small arrows at the top and bottom of the gray scroll-bar.
If you are in the *Activities* section of the course and you want to look up a term displayed in blue (a hotword), you can jump to that term's definition in the *Glossary* by clicking it. You can then return to your page in *Activities* by clicking *Activities* in the top right corner of the page.

IPA Charts

The course contains two charts based on the **International Phonetic Alphabet**. You can go to these charts by clicking **IPA Consonants** and **IPA Vowels**. There are 125 IPA symbols on the charts.

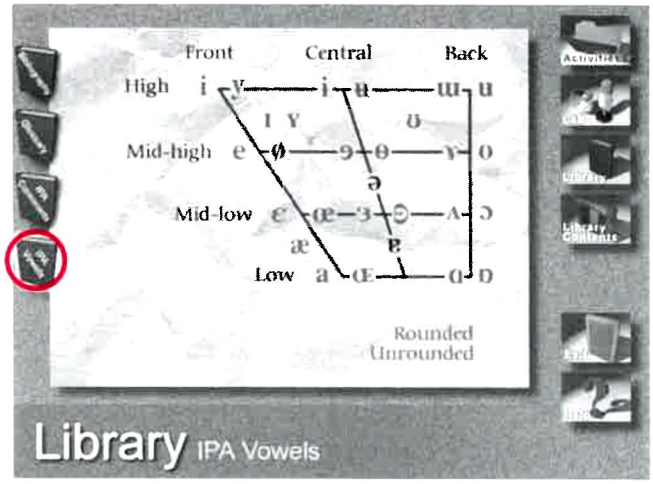
You can go from these charts to the **IPA Samples** page. On the **IPA Samples** page, you can listen to samples of the sounds represented by the IPA symbols. You can also see the spectrograms of the set of pre-recorded IPA samples.

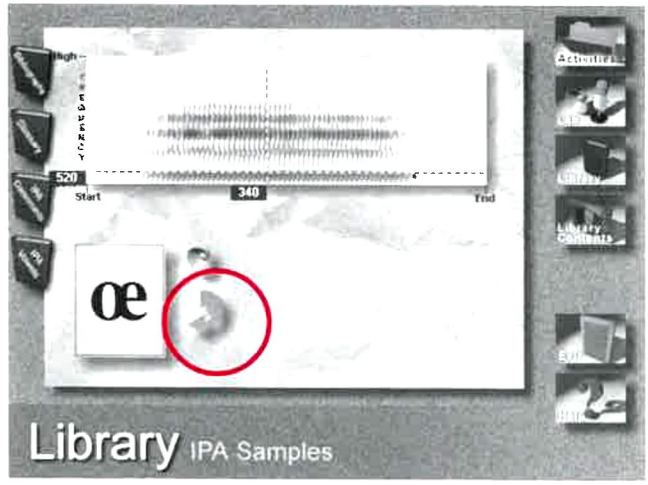


IPA Consonants

The **IPA Consonants** page contains a "folded" version of the IPA consonant chart, with some rows hidden. To see the hidden rows, click a green title on the left side of the chart, then select a row from the menu that will pop up. For example, the top row of the chart shown above is labeled "Plosive". If you click "Plosive", a menu listing "Implosive", "Ejective", and "Aspirated" appears under the chart. Clicking "Ejective" replaces the symbols for plosives with ejective consonants and changes the row title from "Plosive" to "Ejective". To restore the symbols for plain plosives select "Plosive" from the menu. When you are finished looking through the rows of the chart, click the title of the row again to make the menu go away.

If you want to hear one of the consonants on the chart or see a spectrogram of it, move the cursor to it and click. This takes you to the **IPA Samples** page and displays a spectrogram of the consonant between two "ah" vowels. See the description of the **IPA Samples** page for more information. If you only want to hear the sound, hold down a "Shift" key when you click to play a sample recording.





IPA Vowels

The **IPA Vowels** page contains the entire IPA vowel chart. It shows the unrounded vowels in blue and rounded vowels in red. To hear a vowel and see its spectrogram, move the cursor to the symbol for that vowel and click. This takes you to the **IPA Samples** page and shows a spectrogram of the vowel. See the description of the **IPA Samples** page for more information. If you only want to hear the vowel, hold down a "Shift" key and click.

Listening to Spoken IPA Examples

This page allows you to listen to a recorded vowel and see its spectrogram. A spectrogram of the speech sound is shown together with its IPA symbol.

To play the sound, click the loudspeaker icon.

To return to the page you were looking at, click the **Return** arrow. You will be returned to the **IPA Consonants** page if you have examined a consonant and to the **IPA Vowels** page if you examined a vowel.

To go to any part of the *Library*, click one of the buttons on the left side of the page. To go to the *Lab* or *Activities*, get **Help**, return to the *Library Contents* page, or **Exit** the course, click the corresponding button on the right side of the page.

Help

Each page of the course is linked to a page that resembles it in **Help**. Clicking **Help** near the lower left corner of the page takes you to the page of **Help** that most closely resembles the page you are on. You can often learn more about a topic by browsing through the **Help** pages before or after the one you find automatically. The section "Navigating in the **Help** system" below explains how to do this.

Remember that **Help** contains help on running and using the course, not on the concepts and topics covered in the course.

Controls on the page

When the cursor points to an item you can use on a **Help** page, a note explaining that item pops up. Here is how a help page looks before you move the cursor to a "live" item.

This is a list of the units on Basic Acoustics. Click the title of the unit whose contents page you want to go to. (Click now to go to a sample unit contents page.)
• Spectrograms

When the cursor points to one of the unit titles, here, "Spectrograms," a pop-up description appears. The description tells you that these are the titles of units in the course and that clicking one of those titles will take you to the beginning of the corresponding unit.

If you are looking for help for a specific control on the page, you may not see it right away or you may not recognize it when you see it in a different context. Look carefully. For instance, you may be looking for a square blue handle on one kind of graph and not see that the same square blue handle is on the **Help** screen in a different kind of graph.

Navigating in the Help system

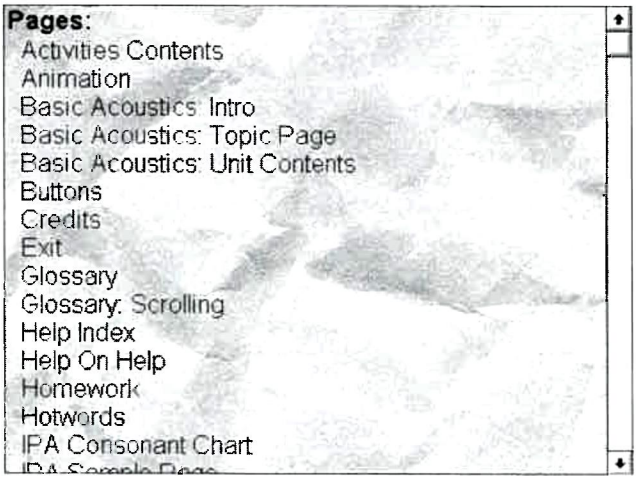
To see **Help** on other activities or similar activities, use the buttons described below to find your way through the help system.

Each page of the **Help** system contains a **Last Topic** and a **Next Topic** button. If you repeatedly click **Next Topic**, you will go through a sequence of **Help** pages that roughly correspond to the normal sequence of pages in an assignment in the course. For instance, if you start at the **Help** for an introduction page and click **Next Topic**, you will go to the **Help** for a topic page. Clicking **Next Topic** again takes you to the **Help** for a typical activity.

The **Last Topic** button returns you to the previous page in the sequence. For example, if you are at the **Help** for an introduction page, clicking **Last Topic** returns you to the **Help** for the unit contents page. Clicking **Last Topic** again returns you to the **Help** for the *Activities Contents* page.
You can use the **Help** Index, described below, to search for help on a specific activity.

Help Index

Go to the **Help Index** from any page of **Help** by clicking **Index**. The **Index** button is on the bottom edge of the help screen.



The **Help Index** contains a list of topics and a list of names of **Help** pages like the one shown here. Scroll through the list by dragging the slider up and down the scroll bar on the right side of the list or by clicking the up and down arrows at the top and bottom of the scroll bar. When you have found the topic you want, click the topic in the list to go to the corresponding page of **Help**.

Exit Help

When you are finished finding help, click **Exit Help**. This returns you to the page of the course you were reading before you clicked **Help**.

Note on the IPA Font Used

The IPA Kiel font used in this work is available from Linguist's Software, Inc., P.O. Box 580, Edmonds WA 98020-0580, (206)775-1130.

SENSIMETRICS

Sensimetrics Corporation
26 Landsdowne Street
Cambridge, Massachusetts 02139
products@sens.com
(617) 225-2442
(617) 225-0470